LEAD USER ANALYSES FOR THE DEVELOPMENT
OF NEW INDUSTRIAL PRODUCTS

by
Glen L. Urban
and
Eric von Hippel
Massachusetts Institute of Technology, Cambridge, MA
Alfred P. Sloan School of Management, W.P. #1797-86

## ABSTRACT

Recently, a "lead user" concept has been proposed for new product development in fields subject to rapid change (von Hippel, 1986). In this paper we integrate market research within this lead user methodology and report a test of it in the rapidly evolving field of computer-aided systems for the design of printed circuit boards (PC-CAD). In the test, lead users were successfully identified and proved to have unique and useful data regarding both new product needs and solutions responsive to those needs. New product concepts generated on the basis of lead user data were found to be strongly preferred by a representative sample of PC-CAD users. We discuss strengths and weaknesses of this first empirical test of the lead user methodology, and suggest directions for future research.

# LEAD USER ANALYSES FOR THE DEVELOPMENT OF NEW INDUSTRIAL PRODUCTS

## 1.0: Introduction

One important function of marketing research is to accurately understand user needs for potential new products. Such understanding is clearly an essential input to the new product development process (Rothwell, et.al. 1974, Urban and Hauser, 1980). Over the past decade, empirical research has shown that, in many fields, users have a great deal more to contribute to the inquiring marketing researcher than data regarding their unfilled needs. Often, they can contribute insights regarding solutions responsive to their needs as well. This "solution" data can range from rich insight to working and tested prototypes of the desired novel product, process, or service. In some fields, users have been shown to be the actual developers of most of the successful new products eventually commercialized by manufacturers. For example, users were found to be the actual developers of 82% of all commercialized scientific instruments studied and 63% of all semiconductor and electronic subassembly manufacturing equipment innovations studied (von Hippel, 1976, 1977).

In a previous paper, von Hippel (1986) has proposed that analysis of need and solution data from a "lead users" can improve the productivity of new product development. In this paper we enhance the lead user methodology by adding modern market research techniques and then test it in one industrial setting.

"Lead users" of a novel or enhanced product, process or service are defined as those who display two characteristics with respect to it:

- Lead users face needs that will be general in a market place - but face them months or years before the bulk of that market-place encounters them, <u>and</u>

- Lead users are positioned to benefit significantly by obtaining a solution to those needs.

Thus, a manufacturing firm with a current strong need for a process innovation which many manufacturers will need in two years' time would fit the definition of lead user with respect to that process.

Each of the two lead user characteristics specified above provides an independent and valuable contribution to the type of new product need and solution data lead users are hypothesized to possess.

The first is valuable because, as studies in problem-solving have shown (summarized in von Hippel, 1986), users who have real-world experience with a need are in the best position to provide market researchers with accurate (need or solution) data regarding it. When new product needs are evolving rapidly, as in many high technology product categories, only users at the "front of the trend" will presently have the real-world experience which manufacturers must analyze if they are to accurately understand the needs which the bulk of the market will have tomorrow.

The utility of the second lead user characteristic is that users who expect high benefit from a solution to a need can provide the richest need and solution data to inquiring market researchers. This is because, as has been shown by studies of industrial product and process innovations (Mansfield, 1968), the greater the benefit a given user expects to obtain from a needed novel product or process, the greater his investment in obtaining a solution will be.

In sum, then, lead users are users whose present strong needs will become general in a marketplace months or years in the future. Since lead users are familiar with conditions which lie in the future for most others, we hypothesize that they can serve as a need-forecasting laboratory for marketing research. Moreover, since lead users often attempt to fill the need they experience, we hypothesize that they can provide valuable new product concept and design data to inquiring manufacturers in addition to need data.

## 2.0: Methodology

The integration of market research methods with the lead user hypothesis can be represented by a four step methodology for concept development and testing. These steps are:

### 1) Specify Lead User Indicators

#### A. Find market or technological trend and related measures:

Lead users are defined as being in advance of the market with respect to a given important dimension which is changing over time. Therefore, before one can identify lead users in a given product category of interest, one must specify the underlying trend on which these users have a leading position, and must specify reliable measures of that trend.

B. Define measures of potential benefit:

High expected benefit from solving a need is the second indicator of a lead user, and measures or proxy measures of this variable must also be defined. In work to date, we have found three types of proxy measures to be useful. First, evidence of user product development or product modification can serve as a proxy for user benefit because, as we noted previously, user investment in innovation and user expectations of related benefit have been found to be correlated. Second, user dissatisfaction with existing products (services or processes) can serve as a proxy for expected benefit because it is logical that the degree of dissatisfaction with what exists will be correlated with the degree of expected benefit obtainable from improvements. Finally, speed of adoption of innovations may also serve as a surrogate for high expected benefit. Early adoption and innovativeness have been found often correlated with the adopter's perception of related benefit (Rogers and Shoemaker, 1971).

## 2) Identify Lead User Group

Once trend and benefit indicators are specified, one may screen the potential market based on the measures specified above via questionnaire and identify a lead user group. This is accomplished by a cluster analysis of the survey-based lead user indicators to find a subgroup which is at the leading edge of the trend being studied and displays correlates of high expected benefit.

## 3) Generate Concept (Product) with Lead Users

The next step in the method involves deriving data from lead users related to their real-life experience with novel attributes and/or product concepts of commercial interest. This experience may include modifications to existing products or new products which they have created to meet their needs. Creative group sessions can be used to pool user solution content and develop a new product concept.

### 4) Test Lead User Concept (Product)

The needs of today's lead users are typically not precisely the same as the needs of the users who will make up a major share of tomorrow's predicted market. Indeed, the literature on diffusion suggests that, in general, the early adopters of a novel product or practice differ in significant ways from the bulk of the users who follow them (Rogers, 1962). One therefore next assesses how lead user data is evaluated by the more typical users in the target market. This can be done by employing traditional concept (product) test procedures after segmenting lead and non-lead user responses.

## 3.0: Application

Can lead user solution content captured through the proposed four step market research methodology be the basis of successful new industrial product development? In this section we report one clinical case study which addresses this question. Through this in depth case study we hope to make clear the detailed procedures and issues involved in implementing the lead user concept, and provide one data point for determining the value of lead user input.

As the reader will see, the results of our single case analysis appear very successful. While the generality of such results must be ascertained by additional research, we think that this initial case offers a graphic illustration of the potential utility of marketing research analyses of lead users.

Our case study focuses on computer aided design (CAD) systems. We picked CAD products for our case study because it is a large, growing, and rapidly changing market. Over forty firms compete in the one billion dollar market for CAD hardware and software. This market grew at over 35 percent per year over the period of 1982 to 1986 and the forecast is for continued growth at this rate until 1990. We feel it represents an appropriate arena for a test of lead user methodologies.

Within CAD, we decided to specifically examine the CAD systems used to design the printed circuit boards used in electronic products, PC-CAD. Printed circuit boards hold integrated circuit chips and other electronic components and interconnect these into functioning circuits. PC-CAD systems take engineering designs and convert them into detailed manufacturing specifications for such printed circuit boards. The steps in the design of a printed circuit board which are or can be aided by PC-CAD include component placement, signal routing (interconnections), editing and checking, documentation, and interfacing to manufacturing. The software required to perform these tasks is very complex and includes placement and routing algorithms and sophisticated graphics. Some PC-CAD manufacturers sell only such software, while others sell systems which include both specialized computers and software.

### 3.1: Specifying Lead User Indicators

The first step in the methodology we have proposed is to examine the technology and benefit dimensions and develop quantifiable indicators for the later steps of screening and lead user group definition.

**Identifying An Important Trend**: Our first step in investigating lead user data in PC-CAD was to identify an "important" trend in that field. To do this, we sought out a number of engineers who were expert users of PC-CAD systems. We identified such experts by telephoning managers of the PC-CAD groups of a number of firms and asking each: "Who do you regard as the engineer most expert in PC-CAD in your firm? Who in your company do group members turn to when they face difficult PC-CAD problems?"

After our discussions with expert users, it was qualitatively clear to us that an increase in the "density" with which chips and circuits are placed on a board was and would continue to be very important trend in the PC-CAD field. Historical data showed that board density had in fact been steadily increasing over a number of years and the value of continuing increases in density was clear. An increase in density means that it is possible to mount more electronic components on a given size printed circuit board. This, in turn, translates directly into an ability to lower costs (less material is used), to decreased product size, and to increased speed of circuit operation (signals between components travel shorter distances when board density is higher). Very possibly, other equally important trends exist in the field which would reward analysis, but we decided to focus on this single trend in our present study.

Printed circuit board density can be increased in a number of ways, and each of these offers an objective means of determining a respondent's position on the trend towards higher density. First, the number of layers in a printed circuit board can be increased. Early boards contained only one or two layers, but now some manufacturers are designing boards with 20 or more layers. Second, the size of electronic components can be decreased. A recent important technique for achieving this is "surface mounted devices" which are soldered directly to the surface of a printed circuit board rather than being built with legs that fit into drilled holes in the board. Finally the printed wires (called "vias") which interconnect the electronic components on a board can be made narrower and packed more closely together. Questions regarding each of these density related attributes were included in our formal screening questionnaire. We asked for the number of layers and line width for an average board design and if the firms had used surface mounted devices.

**Measures of Potential Benefit:** Next, we assessed the level of benefit which a respondent might expect to gain by improvements in PC-CAD. First, we asked whether respondents had developed and built their own PC-CAD systems, rather than buy the commercially available systems such as those offered by IBM or Computervision. Next we asked about users' level of satisfaction (seven point satisfaction scale) with existing commercially available PC-CAD equipment, In order to identify early adopters of the technology we determined when the firm first started to use PC-CAD. Finally, we asked respondents to rate the innovativeness of their firm in the field of PC-CAD by selecting the one statement out of four that best described them: (1), Adopt new technology only after well established and standardized; (2), In the mainstream of technology within our industry; (3), Up to date with new technology, but not necessarily first; (4), Always at the leading edge of technology.

### 3.2: Identifying Lead User Group

In order to identify lead users of PC-CAD systems capable of designing high density printed circuit boards we had to find that subset of users who were: (1) designing very high density boards now and (2) were positioned to gain especially high benefit from increases in board density. We decided to use a formal telephone screening questionnaire to accomplish this task and designed one which contained the objective indicators discussed above. The sample was selected from two sources: a list of members of the relevant professional engineering association (IPC Association) and a complete list of current and potential customers provided by a very large cooperating supplier. Interviewees were selected from both lists at random. In 1985 we contacted approximately 178 respondents who qualified as PC-CAD users, supervisors, or technical support personnel. They answered the screening questions on the phone or by mail if they preferred. The cooperation rate was good -- 136 screening questionnaires were returned(76.4%). One third of these were completed by engineers or designers, one third by CAD or printed circuit board managers, 26 percent by general engineering managers, and 8 percent by corporate officers.

Simple inspection of the screening questionnaire responses showed a number of items of interest. First, and perhaps most surprising to those not familiar with user innovation, we found that fully 23 percent of all responding user firms had developed their own in house PC-CAD hardware and software systems. Prior to the survey, suppliers of PC-

CAD software had indicated that user development would be rare because of the high cost of development and the expertise required. In contrast we found many who allocated substantial resources to build systems that satisfied their needs. One user devoted more than 25 man years over a two year period to develop a system that would meet its own advanced requirements. Users who did develop their own systems reported that they were seeking to achieve better performance than commercially available products could provide in several areas: high routing density, faster turn-around time to meet market demands, better compatibility to manufacturing, interfaces to other graphics and mechanical CAD systems, and improved ease of use for less experienced users.

The high proportion of user-innovators which we found in our sample is probably representative of the general population of PC-CAD users. It was random among a comprehensive list of potential users and the questionnaire had an acceptable response rate. Our sample was well dispersed across the self-stated scale with respect to innovativeness (24 percent indicated they were on the leading edge of technology, 38 percent up to date, 25 percent in the mainstream, and 13 percent adopting only after the technology is clearly established). This self-perception is supported by objective behavior with respect to the time at which our respondents adopted PC-CAD: Half began using CAD between 1979 and 1985, 33 percent between 1974 and 1978, and 21 percent before 1969.

We conducted a cluster analysis of screening questionnaire data relating to the hypothesized lead user characteristics in an attempt to identify a lead user group. The two and three cluster solutions are shown in Table One. The analyses do indeed clearly indicate a group of respondents who combine the two hypothesized attributes of lead users.

**Table 1: Cluster Analyses Show User Group With Hypothesized Lead User Characteristics**

| | Two cluster Solution | | Three cluster solution | | |
|---|---|---|---|---|---|
| | 2.1 | 2.2 (lead user) | 3.1 | 3.2 (lead user) | 3.3 |
| Measures of Density Trend | | | | | |
| Surface Mount (%) | 56 | 87 | 100 | 85 | 7 |
| Avg.Line Width (mils) | 15 | 11 | 13 | 11 | 17 |
| Avg. Layers (number) | 4.0 | 7.1 | 4.4 | 6.8 | 4.2 |
| Measures of Potential Benefit | | | | | |
| Build own PC-CAD (%) | 1 | 87 | 0 | 100 | 0 |
| Innovativeness* | 2.4 | 3.3 | 2.8 | 3.2 | 2.1 |
| Satisfaction** | 5.3 | 4.1 | 5.2 | 4.1 | 5.2 |
| First use CAD (yr) | 1980 | 1973 | 1979 | 1973 | 1980 |
| Number in Cluster | 98 | 38 | 57 | 33 | 46 |

* 4 point scale-- high value more innovative
** 7 point scale-- high value more satisfied with commercial products

In the two-cluster solution, the lead user cluster (2.2) is clearly distinct from cluster 2.1 on all attributes measured. In line with our hypothesis, members report more use of surface mounted components, narrower lines, and more layers. Many more respondents in the lead user group report building their own PC-CAD system (87 percent versus 1 percent), judge themselves to be more innovative (3.3 versus 2.4 on the four point scale with higher values more innovative) , are earlier adopters (seven years), and are more dissatisfied with commercially available systems (4.1 versus 5.3 with higher values indicating satisfaction). Twenty eight percent of our respondents are classified in this lead user cluster. The two clusters explained 24 percent of the variation in the data.

In the three cluster solution the lead user group profile(3.2) was similar to the two cluster lead group (2.2), but the non-lead group (2.1) was separated into two sub-groups. Group 3.3 had the lowest use of surface mounted components, widest line widths, fewest layers, latest year of adoption, and rated itself as lowest on adoption of innovations. In the three cluster solution 37 percent of the variation was explained by cluster membership.

Given the robustness of the lead user profile, we selected the two cluster solution as the more parsimonious basis for further analysis. A discriminant analysis on lead group membership indicated that "build own system" was the most important indicator of the lead user cluster. The discriminant analysis had 95.6% correct classification of cluster membership and the standardized discriminant function coefficients were: Build own .94, self stated innovativeness .27, average number of layers .25, satisfaction -.23, year of adoption -.16, surface mounting .15.

### 3.3: Developing A Lead User Product Concept

The next step in our analysis was to select a small sample of the lead users identified in our cluster analysis to participate in a creative group exercise to develop one or more concepts for improved PC-CAD systems. Experts from five lead user firms which had facilities located near MIT were recruited for this group. The firms represented were Raytheon, DEC, Bell Labs, Honeywell, and Teradyne. Four of five firms had built their own PC-CAD systems. All were working in high density (many layers and narrow lines) applications, and had adopted the CAD technology early. While not necessarily representative of the population they all were lead users and possessed solution content.

The task set for this group was to specify the best PC-CAD system for laying out high density digital boards that could be built with current technology. To guard against the inclusion of "dream" features impossible to implement, we conservatively allowed the concept the group developed to include only features which one or more of them had already implemented in their own organizations.

The PC-CAD system concept developed by our lead user creative group integrated the output of PC-CAD with numerical control machines, had easy input interfaces (e.g. block diagrams, interactive graphics, ICON menus), and stored data centrally with access by all systems. It also provided the capability of full functional simulation (e.g.

electrical, mechanical, and thermal), designing boards of up to 20 layers, routing thin lines, and locating surface mounted devices on the board. These improvements were in the same direction as the objectives reported in our questionnaire by our users who had built their own systems.

### 3.4: Testing Lead User Product Concept

To test whether lead users and more ordinary users preferred the new PC-CAD system concept generated by the lead user group, we decided to obtain comparative ratings on four systems: each user's currently used PC-CAD system; the best commercial PC-CAD system available at the time of the study (as determined by a large PC-CAD system manufacturer's competitive analysis); the system concept developed by the lead user group; and a system for laying out curved printed circuit boards. The curved board concept was a special-purpose system which one lead user had designed to lay out boards in three-dimensional shapes. This is a useful attribute if one is trying to fit the oddly-shaped spaces inside some very compact products (e.g. telephone hand sets), but we suspected many users would gain no practical benefit from its use. We included the curved board concept in our test to detect the presence of a "yea saying" bias. If it received a response as favorable as the lead user concept either a response bias would be indicated or our prior of low potential would be wrong.

To obtain user evaluations of our four PC-CAD systems, we prepared one-page descriptions of three of them (all but "user's current system"). To avoid respondent bias, these descriptions were labeled simply "J, K, and L". We then designed a new questionnaire which contained measures of both user perception and preference regarding the four systems being compared.

The questionnaire asked respondents to first rate their current PC-CAD system on 17 attribute scales which had been generated by a separate sample of users through triad comparisons of alternate systems, open ended interviews, and technical analysis. Each scale was presented to respondents in the form of a five point agree-disagree judgement based on a statement such as "my system is easy to customize".[1]

Next, each respondent was asked to read the one page descriptions of each of the three concepts we had generated and rate these on the 17 perceptual scales. All three concepts were described as having an identical price of $150,000 for a complete hardware and software work-station system able to support four users. Rank order preference and constant sum paired comparison judgments were requested for the three concepts and the existing system. Finally, probability of purchase measures on an 11 point Juster scale were collected for each concept at the base price of $150,000 and alternate prices of $100,000 and $200,000.

Our second questionnaire was sent to 173 users (the 178 respondents who qualified in the screening survey less the five user firms in the creative group). Respondents were called by phone to inform them that a questionnaire had been sent. After telephone follow up and a second mailing of the questionnaire, 71 complete or substantially complete responses were obtained (41%) and the analyses which follow are based on these.[2]

**Lead User Concept Preference:** Our analysis of the concept questionnaire showed that respondents strongly preferred the lead user group PC-CAD system concept over any other (see Table 2). 78.6 percent of the sample selected the lead user creative group concept as their first choice. The constant sum scaled preference value was 2.60 for the concept developed by the lead user group. This was thirty nine percent greater than users' preference for their own current system and

---

[1] The seventeen attributes were: Ease of customization, integration with other CAD systems, completeness of features, integration with manufacturing, maintenance, upgrading, learning, ease of use, power, design time, enough layers, high density boards, manufacturable designs, reliability, placing and routing capabilities, high value, and updating capability.

[2] 94 individuals (55%) actually returned the questionnaire, but only 71 were judged complete enough to use. This subset consists of 61 respondents who completed all items on both the screening and concept questionnaires, and an additional 10 who completed all items except the constant-sum paired comparison allocations.

more than twice as great as the preference for the most advanced existing commercially available product offering.

The concept created by the lead user group was significantly more preferred than users' existing systems at the 10 percent level based on the preference measures (t=12 for proportion first choice and t=2.1 for constant sum). The lead user group concept also was significantly better than the user system for designing curved PC boards (called "specialized user system" in all Tables) on these measures at the ten percent level (t=12.3 for first choice, t=7.9 for preference). Convergent results were indicated by the probability of choice measures. The lead user group concept had a probability of purchase of 51.7 percent and was significantly higher than the two other concepts at the ten percent level. The low preference for the specialized user system argues against a yea saying or demand effect bias -- respondents did not uniformly evaluate positively all new concepts.

**Table 2: Test of All Respondents' Preferences Among Four Alternative PC-CAD System Concepts**

| PC-CAD Concept | Percent First Choice | Constant Sum* | Average Probability of Purchase |
|---|---|---|---|
| Respondents' Current PC-CAD | 9.8 | 1.87 | ** |
| Best System Comm'ly Avail. | 4.9 | .95 | 20.0 |
| Lead User Group Concept | 78.6 | 2.60 | 51.7 |
| Specialized User System | 6.5 | .77 | 26.0 |

* Torgerson, 1958
** Probability of purchase only collected across concepts

Non-response bias was examined by comparing early and later returns. Returns from the first 41 percent of respondents, showed 77 percent choice for the lead user concept and the last 59 percent showed 71 percent first choice. These differences were not significant at the ten percent level (t=.15). Thus there was no apparent evidence of a non-response bias in the preference for the lead user concept.

Respondents maintained their preference for the lead user concept even when it was priced higher than competing concepts. The effects of price were investigated through the probability of purchase measures collected at three prices for each concept. For the lead user concept, the probability of purchase increases from 51.7 percent to 63.0 percent when the price is decreased from $150,000 to $100,000 (t=2.3) and drops to 37.7 percent when the price is increased to $200,000. The lead user group concept was significantly higher at all price levels (t greater than 4.4 in all paired comparisons) and this concept was preferred to the best available concept even when the price was twice as high. All three concepts displayed the same proportionate change in purchase probability as the price was changed from its base level of $150,000. The probability measures indicate substantial price sensitivity and provide a convergent measure on the attractiveness of the concept based on lead user solution content.

**Reasons Lead User Concept Preferred:** In order to better understand the reasons for our respondents' preference for the PC-CAD system developed by our lead user group, we investigated the attribute ratings contained in our concept questionnaire.

We factor-analyzed the ratings and selected five dimensions. The principal components five factor solution explained 66 percent of the variation and the eigen value of the last factor was 1.0. The six factor solution explained only 5 percent more variation, the sixth eigen value dropped to .81, and the final factor was not clearly interpretable. The five factor interpretation was supported by a common factor analysis. The same loading structure was observed and the same number of dimensions indicated. These dimensions were: 1.

"Power/value" (loadings of more than .6 were found on attributes of placement/ routing power, value for the dollar, powerful, and high density), 2. "Ease of use" (high loading on easy to learn and easy to use), 3. "Manufacturable" (high loadings were found on manufacturable and enough layers for my needs), 4. "Integratibility" (high loadings on easy to customize, integrate with manufacturing and other CAD systems), and 5. "Maintenance/ upgrading" ( high loadings on easy to maintain, upgrade, and reliable).

The importance of the five dimensions to users were estimated by a linear regression of the individual constant sum preference values by the factor scores and a dummy variable for each concept. The most important were found to be power/value (coefficient of .54), integratibility (.38). Manufacturable (.21) ease of use (.16) and maintain/upgrade (.13) were found to be less important. The regression was significant at the 10 percent level (F(9,230)=14.4) and the R squared value was .36. All t statistics were significant at the ten percent level except maintain/upgrade which was significant at the 15 percent level.

The perceptual maps from our analysis of the rating data showed the lead user-developed concept to be higher than other concepts on a power/value and integration dimension, but lower on manufacturable, and maintenance/upgrade dimension and the same on an ease of use dimension. The existing system excelled on manufacturable but was lower on other dimensions. On the basis of this analysis, it appears that the appeal of the lead user concept could be improved still further if users in general were convinced that the system would be easy to maintain and upgrade, and would specify board designs which are simple enough to be produced without difficulty.

<u>Evaluations of Lead and Non-Lead Users Compared</u>: If lead user data is to be valuable for the design of products which will be successful in the wider marketplace, it is important that the product preferences of typical users are now (or will be later, when the product is commercialized) similar to the preferences of lead users. We have found in this particular study, that the preferences of lead and

non-lead users are similar.

When, as in Table 3, we look at lead and non-lead user clusters separately, the overall similarity of preferences in these groups is apparent. A few differences are worth noting, however. While both groups preferred the concept developed by the lead user creative group, a slightly higher proportion of lead users selected that concept as their first choice (92.3 percent versus 80.5% in the non-lead group). The constant sum preference also higher for the lead group (3.20 versus 2.37), a difference which is significant at the 10 percent level (t=2.0). Lead users were somewhat less likely than other user respondents to switch from their existing system to one of the three alternative concepts presented - the sum of the probabilities is lower (79.6 versus 105.0). But if they did switch, they were more likely to switch to the lead user group concept (Probability of lead users choosing the lead user concept is 53.1 / 79.6 = .67 and for non-lead users 51.2 / 105.5 = .49).

**Table 3: Concept Preferences of Lead vs Non Lead Users**

| CONCEPT | LEAD USER CLUSTER (2.2) (N=17) | | | NON-LEAD CLUSTER (2.1) (N=43) | | |
|---|---|---|---|---|---|---|
| | % First Choice | Constant Sum | Probability of Choice | %First Choice | Constant Sum | Probability of Choice |
| Respondent's Current PC-CAD | 7.7 | 2.64 | -- | 11.1 | 1.56 | -- |
| Best System Comm'ly Avail. | 0 | .67 | 10.2 | 2.8 | 1.06 | 23.9 |
| Lead User Group Concept | 92.3 | 3.20 | 53.1 | 80.5 | 2.37 | 51.2 |
| Specialized User System | 0 | .52 | 16.3 | 5.6 | .87 | 29.9 |

**Underlying Reasons For Preference Similarities Between Lead and Non Lead Users**: We have seen that both lead and non-lead users preferred the PC-CAD system concept developed by the lead user creative group. This is certainly an encouraging outcome for the potential utility of lead user analyses. To understand our finding of similar preferences at a somewhat deeper level, we examined and compared data on the evaluative structures of our lead and non-lead users groups.

Our comparison of the evaluative structures of lead and non-lead users began with an examination of the attribute ratings and factor analyses derived from each group. In both groups five factors were indicated and variation explained was similar (67.8 for lead and 67.7 for non-lead). The factor loadings were also similar for the two groups, and their interpretation suggested the same dimension labels. Thus, lead and non-lead users appeared to be using a similar set of dimensions to evaluate PC-CAD concepts.

We next assumed the same underlying structure of dimensions for both groups and tested for any differences in the importances of each dimension for lead and non-lead users. We performed regressions against the constant sum preferences with variables of: factor scores on the five dimensions, zero or one to reflect lead/non-lead groups, and dummy variables for each product. All these regressions were found significant at the ten percent level (see Table 4). Although there are some differences between the coefficients across the two groups, a Chow test for the difference in the set of coefficients fails to indicate significance (F(8,222)= 0.8.

Pooled importance coefficients are all significant at the ten percent level except for maintenance/upgrade which is significant at the 15 percent level. The lead user group had a somewhat higher preference level (significant at the 15 % level -- see dummy variable coefficient in Table 4).

These results were supported when we regressed the factor scores and dummy variables (lead/non-lead, concept, and prices) on the absolute probability of purchase values for the new concepts. The Chow test showed no significant difference between the two groups and the pooled results indicated all the importance coefficients to be significant at the ten percent level.

One new finding from this additional probability of purchase analysis was that the dummy variable for the lead user group was significant and reflected a lower average probability of purchase

**Table 4 -- Preference Regression**
**For Lead and Non-lead User Clusters**

| COEFFICIENTS (t) | LEAD USERS | NON-LEAD USERS | POOLED |
|---|---|---|---|
| Constant | .96 (2.1) | 1.12 (5.5) | .99 (5.0) |
| FACTOR SCORES | | | |
| Power/value | .53 (2.1) | .49 (4.5) | .54 (5.7) |
| Ease of Use | .18 ( .8) | .16 (1.7) | .16 (1.8) |
| Manufacturable | .25 (1.0) | .19 (1.6) | .21 (1.9) |
| Integratibility | .32 (1.5) | .28 (2.1) | .38 (3.6) |
| Maintain/upgrade | -.03 (-.1) | .19 (1.9) | .13 (1.5) |
| DUMMY VARIABLES | | | |
| Best System Comm'ly Available | 1.51 (2.0) | .60 (1.6) | .96 (3.0) |
| Lead User Group Concept | 1.63 (2.3) | .74 (2.3) | .87 (3.0) |
| Specialized User System | .07 ( .1) | .04 ( .1) | .07 ( .3) |
| Lead User Cluster | -- | -- | .30 (1.5) |
| F statistic [df] | 5.9 (8,59) | 9.7 (8,163) | 14.4 (9,230) |
| R squared | .45 | .32 | .36 |

for the concepts. That is, after adjusting for differences in attribute ratings, their was a negative group effect. We suspected that this lower probability value for the concepts could be explained in part by the high satisfaction levels observed for their in house proprietary system. When a satisfaction value (satisfaction with in house system if they built their own or maximum rating for existing commercial systems if not) was added to the pooled regression, the maximum satisfaction variable coefficient was negative as hypothesized and significant at the ten percent level ($t= -2.0$). The lead user cluster dummy variable continued to be negative and significant but at a lower absolute level.

In sum, the similarity of the importances found indicates that the differences in the preference evaluations shown in Table 3 are due to attribute evaluation differences across lead and non-lead users rather than a different structure of perception and importances. The richness of the evaluative structures across the two groups is similar, but the level of evaluation was a little lower for the non-lead group. Thus, lead and non-lead groups do appear to evaluate PC-CAD systems with a similar structure.

## 4.0: Discussion

The results of this first empirical application of the lead user methodology appear to us to be very encouraging. Lead users with the hypothesized characteristics were clearly identified; a novel product concept was created based on lead user insights and problem solving activities; and the lead user concept was judged to be superior to currently available alternatives by a separate sample of lead and non-lead users.

But can we suggest anything general on the basis of these results? After all, we have only applied lead user methods to a single case at this point. Perhaps the data base regarding the general utility of lead user methods is not so slim as it might first appear. In our view, the "lead user methodology" is a logically straightforward combination of three components, and each of these components has been empirically tested in other contexts.

First, the lead user method assumes that users who have experience with a need are better able to give accurate information regarding it than those without such experience. Both common sense and several empirical studies on problem-solving support this assumption (von Hippel, 1986). Second, it requires that, in fields where need-related trends exist, some people will experience a need under study before others -- they will "lead" with respect to the trend. This assumption is supported by the body of literature on the diffusion of innovation

(Rogers, 1962, Rogers and Shoemaker, 1971). Third and finally, the method assumes that users will differ on the amount of benefit which they can expect from a solution to a need, and that the amount of effort which they will exert to understand and resolve it will vary with the expected benefit. Again this assumption is supported by some research, in this instance, research focussed on the economics of innovation (Mansfield, 1968).

In sum, the evidence supporting the three underlying assumptions of the methodology plus the case study results seem to us to represent a reasonable basis for a prior hypothesis that lead user analysis can improve the productivity of new product development in industrial markets. However, there are certainly problematic issues which must be explored before we have confidence in this hypothesis.

One problem in the method is accurate trend identification: Currently we rely on a skillful analyst to select an important trend on the basis of judgement (much as product attributes for use in multi-attribute analysis are selected by market research analysts on the basis of judgement and qualitative data). Clearly, it would be useful to improve this method. Given the present state of the art however, one may lessen the chance of error when in doubt by selecting several candidate dimensions and screening lead users on each of them along with the benefit indicators. If the same lead users are identified in each instance, the ideas they generate are likely to span all the candidate dimensions. If they are not, parallel idea generation efforts should be undertaken and the concepts tested with alternative lead user segmentations.

A second problem with the method is that it assumes that the product perceptions and preferences of lead users are or will be similar to non-lead users as a market develops. When this is true, evaluation of the eventual appeal of a lead user product or product concept is straightforward. But what if lead users like the product and non-lead users do not? In this case there are two possibilities: (1) The concept is too novel to be appreciated by non-lead users - but it will later be preferred by them when their needs evolve to resemble those of today's lead users; (2) the concept appeals only to lead users and will never be appreciated by non-lead users even after they "evolve".

In the first case the high response from lead users and low response from others could be compatible with eventual commercial success for the product; in the latter case it would not be. How can we tell the difference? Analysis can help. Some possible indicators that lead user perceptions and preferences do foreshadow those of the general user community are:

- Lead and non-lead users have similar evaluative structures (dimensions and utility weights). In such conditions, present judgments by lead users are likely to foreshadow future choices of non-lead users, because only comprehension is needed to facilitate choice;

- If one classifies non-lead users into classes of expert, experienced, knowledgeable, and unaware users and observes a uniformly more positive response for customers with more expertise, this would suggest wider potential.

Some possible indicators that lead user perceptions and preferences do not foreshadow those of the general user community are:

- Response among lead users is found to be multimodal, suggesting that product potential may be restricted to a sub-segment of lead users;

- A discriminant analysis of user attributes on concept acceptance indicates high correlation with attributes that characterize only a segment of lead users;

- Little or multimodal response in the most expert group of non-lead users.

A final problem which our lead user method faces is one endemic to industrial marketing: What should be done about the multi-person aspect of the decision process? Surveys and analyses are much simpler when a dominant decision influencer is present. If no dominant influencer is present, multiple decision participants must be questioned and their inputs integrated.

In the case study reported on here, we avoided the multiperson issue and concentrated on users and their concept response. If other key decision participants had different decision criteria and weighing the potential we identified may not be real. In such instances, the use of multiperson decision influence matrix or models would be necessary for a comprehensive evaluation. (See Silk and Kalwani, 1982 and Choffray and Lilien, 1980 for a review of the state of the art in these areas.)

## 5.0: <u>Further Research</u>

In addition to the problem areas mentioned above, much can be done to explore, test and improve the lead user methodology, and we offer a few examples.

To date, we have only begun to explore the application of lead user methods to industrial products. Explorations in other areas such as consumer package goods, durable products, and services would also be interesting. Casual observation suggests that such exploration might be fruitful: For example, lead users appear to be present in at least some consumer product areas. Shampoo users added egg (protein) to their shampoos prior to the commercialization of such shampoos; all-terrain bicycles were developed and modified by users in Northern California prior to their commercialization; and athletes are active in developing better sports products (e.g. skiis, running shoes, and tennis rackets).

In our first study, we did not compare the quality of lead user product concepts with those generated by a non-lead group. Instead, we simply assumed on the basis of the research on problem-solving mentioned earlier that ideas generated by the more-experienced lead users would have an advantage. But the relative advantage of lead users probably varies as a function of the type of product and experience at issue, and it would be interesting to examine this.

Our study has focussed on the identification and study of naturally occurring lead users. Perhaps lead users can also be created? It is possible for manufacturers to stimulate user innovation by acting to increase user innovation-related benefit(von Hippel, 1987). If they can also place users in environments which they judge to foreshadow future general market conditions, they may be able to create lead users. Market research studies which allow users to experience prototypes of proposed new products and then test their reactions are a possible step in this direction. (Urban, Roberts, and Hauser, 1986).

We have described the implications of lead users for market research in the concept generation and testing phases of new product development. Perhaps they can be useful after product launch as well? Thus, after launch lead users might be employed as opinion leaders; this tactic is now often employed by firms selling medical products and services. Or lead users might be tracked after product launch as a means of identifying important user modifications and improvements to the initial product. Pre-market forecasting of products has received considerable attention in consumer frequently purchased and durables markets (Silk and Urban, 1978, Pringle, Wilson, and Brody, 1982, and Urban and Roberts, 1986), but none of these models has integrated the notion of lead users and diffusion of innovation across heterogeneous users.

In sum, it is possible that marketing research methods based on analyses of lead users can offer manufacturers a window on the future customer needs in rapidly-moving fields. We hope that others will join us in further exploring and developing this possibility.

## ACKNOWLEDGEMENTS

We are pleased to acknowledge our intellectual debt to our colleague John Roberts, who has offered numerous suggestions and comments on our work over the years. We also thank David Israel-Rosen, Shing Lin, John Workman, Mike Nell, and Anton Theodoresco, who provided valuable research assistance. In addition, we thank the many students in our Spring 1985 Marketing/Technology Interface class who helped gather some of the data used in this study.

Our study was funded in part by research grants from Computervision and GTE Labs. We appreciate this support and also the expert help given us by Glenda Keller, Owen Knox, and Jim Cook of Computervision, and Jim Sorce, Raymond Zibman, Joel Krugler, Dennis Pratt of GTE Labs.

## BIBLIOGRAPHY


Choffray, J. and G. L. Lilien (1980), Market Planning for New Industrial Products. New York: John Wiley.

Mansfield, E. (1968), The Economics of Technological Change. New York: W. W. Norton & Company.

Pringle, L.G., R.D. Wilson, and E. I. Brody, "NEWS: A Decision Oriented Model for New Product Analysis and Forecasting", Marketing Science, 1, 1-30.

Roberts, J .H. and G. L. Urban (1985), "Modeling Multiattribute Utility, Risk, and Belief Dynamics for New Consumer Durable Brand Choice" M.I.T. Working Paper, Cambridge, Ma: Alfred P. Sloan School of Management, M.I.T., Management Science (conditionally accepted).

Rogers, E. M. (1962), Diffusion of Innovations. New York: Free Press.

___________, and F. Shoemaker (1971), The Communication of Innovations: A cross Cultural Approach. New York: Free Press.

Rothwell, R., C. Freeman, et al. (1974), "SAPPHO updated-project SAPPHO phase II," Research Policy, 3, 258-91.

Schmookler, J. (1966), Invention and Economic Growth. Cambridge, Mass.: Harvard University Press.

Silk, A. J. and M. U. Kalwani (1982), "Measuring Influence in Organizational Purchase Decisions", Journal of Marketing Research, 19, 165-81.

___________ and G. L. Urban, "Pre-test Market Evaluation of New Package Goods: A Model and Measurement Methodology", Journal of Marketing Research, 15, 171-91.

Urban, G. L. and J. R. Hauser (1980), Design and Marketing of New Products. Englewood Cliffs N.J.: Prentice Hall.

___________ and J. R. Hauser (1986), "The Value Priority Hypotheses for Consumer Budget Plans", Journal of Consumer Research, 12, 446-62.

___________, J. H. Roberts, and J.R. Hauser (1986), "Premarket Forecasting of New Durable Brands: Models and Managerial Implementation", M.I.T. Working Paper. Cambridge, Ma.: Alfred P. Sloan School of Management.

von Hippel, E. (1976), "The Dominant Role of Users in the Scientific Instrument Innovation Process," Research Policy, 5, 212-39.

______________ (1977), "The Dominant Role of the User in Semiconductor and Electronic Subassembly Process Innovation," IEEE Transactions on Engineering Management, EM-24, 60-71.

______________ (1986), "Lead Users: A Source of Novel Product Concepts" Management Science, July.

______________ (1987), The Sources of Innovation. Oxford University Press: Oxford, England, forthcoming.